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Review title: Examining instruments used to measure knowledge of catheter-associated urinary tract infection prevention in healthcare workers: a systematic review

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Examining instruments used to measure knowledge of catheter-associated urinary tract infection prevention in healthcare workers: a systematic review

Abstract

Background

Catheter-associated urinary tract infection (CAUTI) is the most frequently occurring healthcare associated infection (HAI) among hospitalised patients. Adequate knowledge of CAUTI in healthcare workers supports effective prevention and control of the infection. This systematic review assesses instruments used to assess knowledge of CAUTI prevention in healthcare workers to inform future research. The catheter lifecycle model was used to evaluate the conceptual framework upon which the measurement instruments were based. Finally, the psychometric quality of these instruments was evaluated.

Methods

Five electronic databases were searched for published studies and instruments. The CONsensus-based Standards for the selection of health status Measurement INstruments (COSMIN) checklist was used to assess the psychometric quality reporting of the instruments.

Results

Fifteen studies met the review inclusion criteria and 13 instruments were available for review. Most of the instruments did not address all knowledge components essential for CAUTI prevention as defined by the catheter lifecycle model. The psychometric quality of the instruments was not sufficiently evaluated.

Conclusions

Few instruments are available for CAUTI prevention knowledge measurement. The instruments were not closely aligned with the catheter lifecycle model as a framework. If CAUTI knowledge cannot be measured accurately using an effective instrument, this has the potential to impact negatively on clinical care and the focus of interventions. There is a need for a standardised instrument for the evaluation of CAUTI prevention knowledge so that targeted interventions can address knowledge deficits.

Keywords: catheter-associated urinary tract infection; knowledge; measurement instrument; psychometric quality.

Highlights

- Knowledge of healthcare workers (HCWs) is a focus of CAUTI prevention programmes.
- This is the first systematic review of instruments measuring CAUTI prevention knowledge.
- The instruments' content lacked breadth compared to the Catheter Lifecycle Model.
- The psychometric quality of the instruments was insufficiently evaluated.
- The instruments cannot be recommended for use in research, practice or training.

Introduction

Urinary tract infection (UTI) accounts for about 40% of all healthcare-associated infections.¹ Up to 80% of the healthcare-acquired UTIs are associated with the use of urinary catheters.² The Centres for Disease Control and Prevention (CDC) reported catheter-associated urinary tract infection (CAUTI) as the most occurring healthcare-associated infection.³ Studies have established the multi-faceted impact of CAUTIs as one of the leading causes of patients' morbidity and mortality and they can result in complications which in turn, can cause suffering among family members.⁴⁻⁷ CAUTI is known to significantly increase healthcare costs, for example, through additional treatment and increased length of hospital stay.^{4 5} Furthermore, CAUTI contributes to the ever-increasing global burden of antimicrobial drug resistance due to the inappropriate use of antibiotics as prophylaxis or empirical treatment of suspected infection.⁸

Up to 25% of catheterised patients develop bacteriuria within the first week of catheter insertion.⁹ The risk increases by 5% to 10% with each additional day the catheter remains in situ.⁹¹⁰ Thus, the risk of CAUTI can be significantly reduced by avoiding indwelling catheterisation or reducing the number of catheter days.¹¹ As patients may require a urinary catheter for some healthcare interventions, it cannot always be avoided. However, catheters are often inserted without clinical indication^{11 12} or proper documentation¹³ which could result in an increase in the number of catheter days.

The World Health Organisation sees education and training of healthcare professionals as a core component of infection prevention and control¹⁴ and poor knowledge is seen as one of the key causes of healthcare-associated infections.¹⁵ For CAUTI prevention programmes, it has been demonstrated that incorporating healthcare workers' education into CAUTI prevention programmes helps reduce

catheterisation rates, thereby reducing the incidence of CAUTI.¹⁶ Therefore, improving healthcare workers' knowledge of CAUTI is a crucial step in approaches to its prevention.¹⁷ To prevent and control the development of CAUTI, good standards are required.¹⁸ To achieve standards in CAUTI prevention and control, education and training of healthcare workers on catheter indications, catheter insertion, maintenance, recognition of CAUTI signs and symptoms and early catheter removal are essential.^{18 19} An existing CAUTI education bundle developed by the United States Agency for Healthcare Research and Quality incorporates infection prevention and control aspects such as hand hygiene, patient care equipment and environment, and antibiotic stewardship.²⁰ Similarly, quality improvement projects considered education and training of healthcare workers as one of the key drivers to CAUTI prevention strategies.^{21 22}

Since education is seen as a key component in CAUTI prevention, knowledge measurement establishes whether practitioners' knowledge is sufficient and up to date to contribute to the safety of patients with a urethral catheter. In clinical education and practice, different instruments are used by researchers to assess CAUTI prevention knowledge of healthcare workers. Results obtained using such instruments are relied upon as the level of healthcare professionals' knowledge and competency to safely care for patients requiring/with an indwelling urethral catheter.^{23 24}

Further, knowledge measurement is used to evaluate the effectiveness of educational interventions. A number of educational interventions aimed at improving healthcare workers knowledge of CAUTI prevention have been implemented.²⁵⁻²⁸ These interventions include

indications for catheter placement, routine catheter assessment and infection prevention practices. However, such intervention studies mainly focus on the reduction of CAUTI rates as an outcome.²⁹ Changes in knowledge are often overlooked and specifically, the relationship between improvement in knowledge and CAUTI rates is rarely assessed. Further, the knowledge of CAUTI among healthcare professionals may be sub-optimal.^{24 30-32}

To reliably and validly assess CAUTI prevention knowledge, the instruments (e.g., tests, quizzes) need to undergo a rigorous development and evaluation process to evidence that they meet psychometric standards in the target population.^{33 34} Testing for, and reporting of validity and reliability of a measurement instrument allows critical evaluation whether, and to which degree the instrument reflects the measured concept and the accuracy of obtained scores in differentiating between levels of CAUTI prevention knowledge.³⁵

In order to evaluate the content validity of an instrument, a conceptual model is needed that defines the content areas that should be addressed. In the context of this review, a conceptual model developed by Meddings and Saint³⁶ was adopted. According to this conceptual model, the urinary catheter has a four-stage lifecycle, and an effective CAUTI prevention strategy should address and ensure breaking the lifecycle (Figure I). The lifecycle begins with the insertion of the catheter and continues with the care and maintenance of the catheter and stops when the catheter is removed. The lifecycle then continues if the catheter is re-inserted. Stage one involves decision-making regarding catheter insertion, including strategies to interrupt this stage using alternative approaches to incontinence or to relieve the bladder of urine. This includes healthcare workers training and placement of the catheter using the recommended aseptic techniques. Ensuring staff awareness of the catheter existence and daily catheter need assessment are

examples of components of the second stage. The third stage involves identifying when the catheter is no longer required and timely removal. The last stage of the catheter lifecycle involves interventions such as urinary retention assessment to prevent unnecessary re-insertions and justify the need for re-insertion. The lifecycle then continues if the catheter is re-inserted.

In clinical interventions, targeting at least one component of this model can be an effective way of preventing the development of CAUTI. This has been demonstrated in a narrative review of strategies for CAUTI prevention.¹¹ However, since the development of CAUTI can be minimised by interrupting any component of the lifecycle, it can be argued that training and evaluation tools should address all aspects of the lifecycle model. Therefore, healthcare workers should learn, understand and embed all aspects of the lifecycle model in their day-to-day practice. For this review, we, therefore, define CAUTI prevention knowledge as the theoretical understanding and healthcare workers' knowledge of CAUTI prevention and control.

A previous review on instruments investigating wider compliance with infection prevention and control practices and factors that affect it found that instruments for measuring standard precautions did not address all the components recommended by the CDC.³⁷ This systematic review, therefore, aimed to identify measurement instruments currently available for the evaluation of CAUTI prevention knowledge in healthcare workers and to review whether the existing instruments address the components of CAUTI prevention as specified in the catheter lifecycle model. Additionally, the quality of the reporting of psychometric quality criteria was evaluated.

Methods

Search strategy

Five electronic databases (Medline, CINAHL, ASSIA, Scopus, Web of Science) were systematically searched. Three key terms (healthcare workers, knowledge and CAUTI) were combined using the Boolean operator 'AND' to retrieve studies that contain any of the key terms.³⁸ Related terms and synonyms of the key terms were also combined using another Boolean operator 'OR' to perfect the search and ensure relevant articles were captured. The key terms used for the literature search can be found in Appendix I.

Selection of studies

The review included empirical studies that used a test or quiz to assess the knowledge of CAUTI prevention of healthcare workers such as nurses and doctors. For this literature search, "instrument" was defined as a tool such as a questionnaire or a scale used by researchers to evaluate knowledge of CAUTI prevention. No restrictions were imposed on the design of the studies nor the publication date. Studies had to be available in full-text and published in the English language.

The search results were saved as RIS text format and uploaded into the Endnote reference manager version X8.2.³⁹ After removing the duplicates, the titles of the remaining articles were screened, and studies not relevant to the review topic were excluded. The selection process was carried out by one reviewer (SA), and independently cross-checked by two other reviewers (EB and KS).

Data extraction

In line with the Cochrane's guideline for the conduct of systematic reviews³⁸ a data extraction form was developed and used to identify the key characteristics and other relevant information from the included studies. Due to the focus of the review, only aspects of the studies relating to the measurement instruments were extracted. One instrument⁴⁰ was found to be in the Turkish language, while the main article was published in the English language. To enable the extraction of components and topic areas covered within the scale, a native Turkish speaker translated the instrument to the English language to make the content accessible for the review team. Two authors who are experts in infection prevention and control (SA) and psychometrics (JB) completed the item extraction. The extracted data were mapped on a table using Excel spreadsheet to aid in the narration and integration of findings from the included studies.⁴¹

The PRISMA checklist was used to design and present the review, and the reporting was aligned with the PRISMA guidelines.⁴²

Quality assessment

The quality assessment was completed using the Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist.⁴³ Developed through international Delphi study, the COSMIN tool was designed for the assessment of properties of health measurement instruments. Due to the lack of a specific tool for appraisal of knowledge instruments, the COSMIN tool was considered appropriate for this review since it covers an even wider range of aspects than only those relevant for educational testing.⁴⁴ COSMIN has twelve 'boxes' within four domains. These domains are validity, reliability, responsiveness and interpretability. The validity and reliability domains contain items related to the psychometric quality standard. Validity is the

degree to which a measurement instrument measures the construct it aims to measure.³³ The concept of validity has several components that need to be evaluated before an instrument can be considered valid.³⁵ The reliability of an instrument is the degree to which it consistently reflects inter-individual differences in CAUTI knowledge, i.e. differentiates between healthcare workers with higher and lower levels of such knowledge. If instruments are used to capture CAUTI knowledge levels to evaluate intervention success or the role of knowledge as a mediator leading to reductions in infection rates, they should both be valid and reliable. Since only such instruments can be assumed to reflect the content that we consider relevant for increasing CAUTI safety (validity). More so, only if the scores of such an instrument reflect inter-individual differences to a high degree (reliability) they can successfully be used for group comparisons or as an indicator for knowledge in mediation and other statistical models.

The COSMIN tool has been widely used to evaluate the quality of measurement instruments. The tool was applied without modification and quality criteria were rated 'yes' if addressed, left 'blank' if not addressed/reported and '?' if unsure.

Data synthesis

A narrative approach was used to synthesise data extracted from the primary studies. The approach was considered appropriate because the data required to address the review aim are mainly textual and need no statistical analysis.⁴⁵ The approach was first used to describe and summarise the features of each study.⁴⁶ A framework synthesis was then applied, where the extracted items were mapped against the appropriate component of the catheter lifecycle

framework. Items found outside the components of the model and deemed to be measuring CAUTI prevention knowledge were grouped separately.⁴⁷

Results

Based on titles and abstracts of the 595 articles eligible for consideration, only 28 were suitable for full-text screening. Thirteen articles were further excluded because two articles^{48 49} were not available in full-text, one was only an abstract⁵⁰, another⁵¹ was found to be in the Chinese language, seven studies did not measure knowledge using instrument^{29 52-57}, and two did not use an instrument to measure the participants' knowledge of CAUTI prevention.^{58 59} Fifteen studies met the review's inclusion criteria (figure II). However, only 13 instruments were retrievable as efforts made to obtain instruments used in two studies^{60 61} were unsuccessful.

Only one study⁴⁰ reported the development of a measurement instrument; the remaining 14 studies partly described how their respective instruments were developed, in cross-sectional surveys^{24 30 31 60 62-67} and intervention studies.^{23 61 68 69} The majority of the articles (n=14) reported only general features of the measurement instruments.

Around half of the studies (n=7) were completed in the USA.^{24 62-65 67 68} Others were completed in Australia³⁰, Egypt²³, India^{31 60 61}, New Zealand⁶⁹, Pakistan⁶⁶ and Turkey⁴⁰. The characteristics and summary of the data extracted from the reviewed studies are presented in Table 1.

Table 1. Characteristics and findings of the included studies

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
1.	Arli and Bakan (2018) ⁴⁰	Development of the Catheter-Associated Urinary Tract Infections Control Precautions Scale	200 nurses, Turkey	Cross-sectional. Self-administered hard copy	20-items: CAUTI precaution knowledge and attitude	Literature review and experts' opinion (n = 3)	Structural validity was assessed via exploratory factor analysis (varimax rotation) and three factors were deemed sufficient; no item loading below .62. was observed	Only results for 17 items presented; Cronbach's alpha for three subscale scores and overall score (.89, .75, .58, .75. respectively). Item-total correlations between .479 - .748. Test-retest reliability [20-day interval, n = 30] was estimated at <i>r</i> =.46

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
2.	Shaver et al. (2018) ⁶⁵	Trauma and Intensive Care Nursing knowledge and attitude of Foley catheter insertion and maintenance	48 nurses, USA	Prospective cohort. Face to face written survey	10-item (knowledge) questions on a 4-point scale: Catheter insertion and maintenance	Based on CDC guidelines and concepts identified from a surveillance study by a catheter manufacturer	Not reported	Not reported
3.	Shehab (2017) ²³	Impact of protocol of care of patients undergoing urinary catheterization on nurses knowledge	50 nurses, Egypt	Pre-test post-test design. Hard copies were given to participants before and after sessions	Not stated; Urinary catheterisation knowledge and catheter care	Based on the literature review; no detail about construction provided	Content validity was checked by a jury consisting of a 7-member expert panel	Not reported
4.	Shah et al., (2017) ⁶⁶	Infection control in the use of urethral catheter: knowledge and practises of nurses	70 nurses, Pakistan	Cross-sectional survey. Hard copies of the questionnaire distributed	15-item organised questionnaire: CAUTI knowledge and practise	Self-developed by the authors	Not reported	Not reported
5.	Kaur and Kumar (2015) ⁶¹	Adoption of guidelines on knowledge and	60 nurses, India	One group pre-test post-test design.	15 multiple-choice questions:	Not described	Not reported	Spearman-Brown Coefficient r =

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
		practice regarding care of urinary catheter in situ among staff nurses		Questionnaire distribution method not described	urinary catheter care			.790; Guttman Split-Half Coefficient r = .789
6.	Gesmundo (2016) ⁶⁹	Enhancing nurses' knowledge on catheter-associated urinary tract infection (CAUTI) prevention	13 or 14 nurses (inconsistently reported), New Zealand	Pre-test post-test design. The questionnaire was handed to participants before and after an educational intervention	25-item multiple-choice questions: CAUTI prevention	Adapted from two previous studies ^{70 32}	Not reported	Not reported
7.	Paras et al., (2015) ⁶⁴	Housestaff knowledge related to urinary catheter utilisation and catheter-associated urinary tract infections (CAUTIs)	158 junior doctors, USA	Cross-sectional survey. Internet-based	9-item questions: Catheter utilisation and CAUTI knowledge	Based on the Society for Healthcare Epidemiology of America guideline for CAUTI prevention; no further detail provided	Not reported	Not reported

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
8.	Jain et al., (2015) ³¹	Knowledge and attitude of doctors and nurses regarding indication for catheterization and prevention of catheter-associated urinary tract infection in a tertiary care hospital	154 HCW, India	Cross-sectional survey. Not clearly stated how the questionnaires were distributed to participants	25-item questionnaire: catheterisation knowledge and attitudes; responses on 4-point Likert scale	CDC guideline for CAUTI prevention	Authors independently assessed the questionnaire for simplicity, language clarity, adequacy and accuracy of questions	Not reported
9.	Prasanna and Radhika (2015) ⁶⁰	Knowledge regarding catheter care among staff nurses	30 nurses, India	Descriptive cross-sectional design. E-questionnaire sent to participants	Not stated	Not stated	Not reported	Not reported
10.	Viswanathan et al., (2015) ⁶⁷	Emergency department placement and management of indwelling urinary	129 HCW, USA	Cross-sectional survey	25-item 5-point Likert scale: knowledge, attitude and practice of	Selection from previously published studies ^{24 62 71} vignettes developed by the	Validated by a multidisciplinary expert panel that included the study authors (method of validation, N, and	Not reported

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
		catheters in older adults: Knowledge, attitudes, and practice			CAUTI prevention	team based on literature review	composition of the group not described)	
11.	Drekonja et al., (2010) ⁶²	Foley catheter practices and knowledge among Minnesota physicians	635 physicians, USA	Survey sent via email	115 clinical scenarios for knowledge, and 6 for interventions questions on a 5-point scale	Detailed rationale for content development presented based on published evidence	Known-groups validity test (professional groups GPs vs surgeons; work experience over/under 20 years; teaching vs. non-teaching facilities; presence/absence of guidance at facility)	Not reported
12.	Drekonja et al., (2010) ²⁴	Internet survey of Foley catheter practices and knowledge among Minnesota nurses	370 nurses, USA	Survey sent via email	11 5 clinical scenarios for knowledge, and 6 for interventions	Detailed rationale for content development presented based on published evidence	Known-groups validity test (intensive care nurses; nurses with additional training; work experience	Not reported

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
					questions on a 5-point scale		over/under 20 years; teaching facilities vs non-teaching facilities	
13.	Mody et al., (2010) ⁶³	Knowledge of evidence-based urinary catheter care practice recommendations among healthcare workers in nursing homes	356 HCW, USA	Cross-sectional survey. Hard copies were given to HWC	Item number not clearly stated; 5-point scale on knowledge about indications for indwelling urinary catheter use and urinary catheter care	Based on national (CDC) recommendations	Not reported; the instrument was piloted among n=8 infection control specialist nurses and modifications of individual domains and items were made following their recommendations	Not reported
14.	Smith (2009) ⁶⁸	Effects of an educational intervention on hospital acquired urinary tract infection rates	42 HCW, USA	Pre-test post-test interventional study. The test was done using an e-learning platform	15-item true or false and multiple-choice questions: CAUTI knowledge and infection rates	Based on a clinical guideline for CAUTI prevention and SHEA guideline for prevention of nosocomial infection	Content validity was reported to be achieved by ensuring the knowledge items represent what the healthcare workers should know based on	Cronbach's alpha of .81 Test-retest reliability was evaluated by administering the instrument twice over time.

S/N	Author(s)	Study title	Number of respondents and country	Study design and instrument distribution method	Type of instrument and measured construct	Source(s) used to instrument development	Validity measure	Reliability measure
							their educational background or hospital orientation package. No detail of the procedure reported	Neither N nor results were reported
15.	Fleming et al., (2000) ³⁰	Registered nurse management of urinary catheters in a rehabilitation and long-term care hospital	39 nurses, Australia	Cross-sectional survey. Hard copies were given to participants	36-item multiple-choice questionnaire: Catheterisation knowledge	Based on local catheter selection and management as recommended by continence foundation of Australia	Not reported	Not reported

Note. *CAUTI* Catheter-associated urinary tract infection; *HCW* Health care worker; *CDC* Centre for Disease Control and Prevention; *SHEA* Society for Healthcare Epidemiology of America

Construction of the instruments

Over half (n=8) of the instruments were in the form of Likert scales: four studies used 5-point Likert scales^{24 40 62 67}, three used 4-point Likert scale^{31 64 65} while mixed responses of 6-point Likert scale and dichotomous (yes, no, do not know) were adopted in one study.⁶³ Three studies used yes/no response options^{23 66 68} while multiple-choice questions were the response options in three studies.^{30 61 69} Information about the format of the instrument was not provided in one study.⁶⁰

Items within the instruments were said to be extracted from the CDC guideline^{31 63 65}, Society of Healthcare Epidemiology of America (SHEA) guideline^{64 68}, and the broader literature.^{23 40 67} Two instruments were developed by the same team^{24 62}, first for the assessment of physicians²⁴ and then for the assessment of nurses.⁶²

Components of catheter lifecycle model within the instruments

All knowledge items within the 13 instruments copied verbatim and pasted on Excel spreadsheet. A thematic analysis of the item's content performed. Overall, N=198 items were used in the 13 instruments to measure various aspects of CAUTI prevention. Most of the identified topics (n=70) fell within the component of urinary catheter placement, followed by catheter care (n=62) and background knowledge of CAUTI (n=30). The least measured components were catheter removal (n=9) and catheter re-insertion (n=9). Other topics identified, such as adhering to the basis of sterilisation, are classified as additional precautions (n=6) and prophylaxis (antibiotic plus urine bag additives) (n=4). One question that asked whether physicians should be responsible for catheter insertion⁶² is classified as an opinion. Also, some questions (n=2) about offering a

bedpan or urinal prior perineal care and reducing the frequency of perineal care when a patient is incontinent⁶⁸ could not be categorized within the catheter life cycle model.

Within the catheter placement component, most of the items were related to indications for catheter insertion such as the catheterisation procedure, catheter material for long or short term use, catheter size, insertion skills and alternatives to urethral catheterisation.^{30 31 40 64 69} For the catheter care component, cleaning around the Foley catheter, urethral orifice and perineum area were the most frequent topics^{23 30 31 40 63 65 68 69}, followed by positioning of the drainage bag.^{30 31 63 65 68} Knowledge of closed-drainage systems, securing catheters, care protocols and hand hygiene were also addressed in the catheter care component.^{23 30 31 63 65 68 69} The least frequently mentioned topics within this component were caring for the drainage bag, catheter irrigation and importance of staff education in CAUTI prevention.^{31 63 65 68}

Overall, only one instrument⁶⁹ included items for all the components of the catheter lifecycle model while another⁶³ addressed three components (placement, care, re-insertion). The other instruments mainly addressed two components - catheter placement and catheter care^{23 30 31 40 65 68}, catheter placement and catheter removal.^{24 62 64} Within two instruments^{66 67}, only catheter placement component was addressed. Other aspects of CAUTI prevention not associated with any component of the model were identified within the instruments. These aspects included knowledge of CAUTI^{30 63 65 66 69}, hospital policy on urinary catheter^{23 24 62 63} and category of staff responsible for catheter care documentation.^{64 68} Table 2 shows examples of the question content, response options, and the components of CAUTI prevention based on the thematic analysis.

Table 2: Examples of question content and response options from the instruments (cells; references to original papers provided) organized by components of the CAUTI prevention model (columns; own thematic analysis and Meddings and Saint³⁶)

Components of CAUTI prevention covered within the reviewed instruments							
	Catheter placement	Catheter care	Catheter removal	Catheter re-insertion	Background knowledge	Additional precautions	Prophylaxis
Example 1	<p>Is a Foley catheter indicated in a patient with critical illness and tenuous volume status?</p> <p>Not indicated, Somewhat indicated, Unsure, Usually indicated, Always indicated²⁴ 62</p>	<p>Maintaining a closed drainage system reduces the incidence of CAUTIs</p> <p>Strongly agree, Agree, disagree, Strongly disagree⁶⁵</p>	<p>How effective do you think each of the listed interventions is in preventing catheter-associated urinary tract infections (UTIs)? Having automated reminders to discontinue/renew the order for a catheter</p> <p>Not effective at all, Possibly effective, No effect or unknown effect, Moderately effective, Very effective²⁴ 62</p>	<p>The following measures should be taken for care of residents with an indwelling urinary catheters: when changing a catheter, both the catheter and the drainage bag should be changed</p> <p>Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree, Do not know⁶³</p>	<p>The most common type of healthcare-associated infection (HAI) is:</p> <p>A. Ventilator-associated Pneumonia B. Catheter-associated urinary tract infection (CAUTI) C. Central catheter-associated bloodstream infection (CLABSI) D. Surgical-site infection (SSI)⁶⁹</p>	<p>The following measures should be taken for care of residents with an indwelling urinary catheter: in general, catheterized residents, if not infected can share rooms</p> <p>Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree, Do not know⁶³</p>	<p>How effective do you think each of the listed intervention is in preventing catheter-associated urinary tract infections (UTIs)? Using antimicrobial agents in the drainage bag:</p> <p>Not effective at all Possibly effective No effect or unknown effect Moderately effective Very effective²⁴ 62</p>

Example 2	<p>Is a Foley catheter indicated for urinary incontinence?</p> <p>Not indicated, Somewhat indicated, Unsure, Usually indicated, Always indicated⁴⁸</p>	<p>The following measures should be taken for care of residents with an indwelling urinary catheters: Area around the catheter should be cleaned at least once a day</p> <p>Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree, Do not know⁶³</p>	<p>Indwelling urinary catheters in patients with uncomplicated surgeries should be removed within</p> <p>A. 12 to 24 hours B. 24 to 48 hours C. 48 to 72 hours D. 72 to 96 hours⁶⁹</p>	<p>Changing indwelling catheters or drainage bags at routine, fixed intervals is highly Recommended</p> <p>A. True B. False C. Not sure D. Don't know⁶⁹</p>	<p>Do you know about urinary tract infection (UTI)?</p> <p>Yes No⁶⁶</p>	<p>Do you think residents with MRSA should be isolated to their rooms?</p> <p>Yes No⁶³</p>	<p>Systemic antimicrobial agents are best used routinely as prophylaxis against CAUTI</p> <p>A. True B. False C. Not sure D. Don't know⁶⁹</p>
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Psychometric properties of the instruments

Only one study provided information about the reliability and validity of the measurement instrument.⁴⁰ Six studies evaluated the content validity of the instruments^{23 31 63 67-69} using experts' panels, pilot studies and participants pre-tests performance to validate the instruments. Only Smith⁶⁸ reported testing the instrument's reliability. In two studies, the authors developed a set of items and tested no type of validity nor did they estimate the reliability of the items.^{24 62} Four studies^{30 64-66} did not describe whether the psychometric properties the instruments were assessed or not. The quality assessment results using the COSMIN checklist can be found in appendix II.

In summary, findings from the reviewed articles showed that instruments for the measurement of CAUTI prevention knowledge in healthcare workers largely lack a conceptual definition of what constitutes CAUTI prevention and their psychometric quality was insufficiently evaluated and or reported. The majority of the instruments do not cover the components essential for the prevention of CAUTI as proposed in the life cycle model.³⁶

Discussion

The systematic review explored available instruments used for the measurement of CAUTI prevention knowledge and assessed their conceptual frameworks and psychometric properties. A limited number of instruments for the measurement of CAUTI prevention knowledge were found. None of the instruments was developed for international use and or comparative studies which will make the standardised evaluation of international efforts quite difficult. These instruments were based on various guidelines, and almost none did cover all elements of the

catheter lifecycle. The evaluation and reporting of psychometric properties were limited. It is therefore doubtful whether any of the instruments are comprehensive or of sufficient quality to evaluate CAUTI prevention knowledge in health care workers, either as a mediator or as an outcome variable.

One of the key findings of this review was poor reporting and quality in the development of the measurement instruments. Only content validity was assessed and reported in about half of the studies. Although most of the other instruments were reported to be validated by experts, no detailed process or statistical analysis was reported. Pilot studies were conducted as part of the validation process, in addition to the experts' judgements with small sample sizes which can affect the conclusions that can be drawn on the quality of the instruments.⁷²

Within the 13 instruments, catheter placement and care components were found to be the most frequently addressed constructs. The items were mainly on catheter indications (e.g. agreeing or disagreeing on specific catheter indications), cleaning around the perineal and Foley catheter care. This showed an imbalance in the measurement of other important CAUTI prevention components, such as catheter placement (principally minimising catheter insertions) and catheter removal.⁷³⁻⁷⁵ These findings suggest that the researchers were more concerned with the placement and care of inserted catheters than removal and re-insertion components. These results also align with the findings of a previous study that instruments for assessing broader compliance with infection control practices did not address all the components recommended by the CDC.³⁷

In addition to the potential lack of high-quality development processes revealed by this review, developing a valid and reliable instrument for the measurement of multiple concepts such as knowledge and attitudes or behaviours can be problematic. Previous reviews in related areas have indicated that such instruments can suffer from weak psychometric quality^{76 77} and in the current review over half (n=7) of the instruments were developed to measure multiple concepts. These findings further support the need for strong theoretical foundations from which such instruments need to be developed. The model selected in this review³⁶ is a potential candidate short of using guidance from a specific (inter)national organisation. While our choice was partly a pragmatic one to limit ourselves not to a specific national or agency context as well as wanting to employ a framework with some empirical corroboration,¹¹ the model was supported by our framework analysis as a potentially useful choice for future work in this field. Although none of the instruments were developed based on the lifecycle model and only one instrument covered all its components,⁶⁹ the vast majority of items could nevertheless be allocated to the four components of the model and only two additional domains were identified with very few items allocated to them. This convergence of different theoretical developments and empirical studies lends credibility to the lifecycle model as a useful conceptual approach.

Strength and limitations of the review

This is the first study that has evaluated instruments used for CAUTI prevention knowledge measurement in healthcare workers. One of the strengths of this review is that it represented a comprehensive evaluation of the content and psychometric quality of the CAUTI measurement instruments and was not limited to studies that were explicitly designed to evaluate the

development of instruments. The constructs of the instruments were evaluated against a conceptual model³⁶ for completeness and the psychometric reporting and steps evaluated.⁴³

Key limitations of this review are that we did not consider unpublished studies or studies published in other languages than English. Similarly, the inability to retrieve and include instruments from two studies^{60 61} is another limitation. Other significant limitations of the study are that only one researcher completed the quality appraisal and data extraction. However, the item extraction and quality assessment of the instruments were confirmed by a second reviewer and inconsistencies resolved by discussions of the original studies.

Conclusion

This review demonstrates that there are a limited number of instruments used to assess healthcare workers' knowledge of CAUTI prevention, they only cover parts of the relevant knowledge, and are of poor psychometric quality. Based on the available reports and standard criteria for the evaluation of the content and psychometric quality of such instruments, none of the identified instruments can be recommended for use.^{43 44} This result is surprising because the impact of CAUTI on patient morbidity and mortality,⁴⁻⁷ cost^{4 5} and consequences for the global burden of antimicrobial drug resistance⁸ are well documented and the importance of well-trained healthcare professionals has been voiced by authors^{28 29 49 59 68 69} and guidelines.^{1 3 22}

The focus on education in infection control and prevention¹⁴⁻²² needs to be seen within the context of the wider literature on education as an improvement intervention suggesting that its impact on behaviour change is potentially limited.⁷⁸ One should nevertheless keep in mind that if no instruments are available to measure CAUTI prevention knowledge validly and reliably (as

our review suggests; be it as an endpoint or mediator connecting interventions to behavioural and quality outcomes), then our options to investigate this relationship within the field of (CAUTI) infection prevention and control remain severely limited. If staff with high levels of CAUTI prevention knowledge are seen as one key building block of successful prevention strategies,^{16 17 20 21 22 14} further research is needed to develop a valid and reliable measurement instrument. Guidelines from professional contexts measuring knowledge and similar types of performance⁴⁴ or health-related research with a history of psychometric assessment and its quality control^{79 80} could be used as an orientation for such developments. The minimal considerations such instruments need to fulfil are widely agreed^{44 79 81 82} as (i) a defined construct that the scale intends to measure, ideally based on a conceptual framework; (ii) iterative steps of content validation engaging experts and members of the target population; (iii) iterative steps of evaluating the quantitative psychometric quality, structure, and fairness; and (iv) in this case likely also providing normative references to enable cross-study and cross-setting comparisons. Without such an instrument the evaluation of the effectiveness of educational interventions aimed at improving CAUTI prevention knowledge is severely limited, and the potential of monitoring staff training levels for professional or organisational development purposes is impossible.

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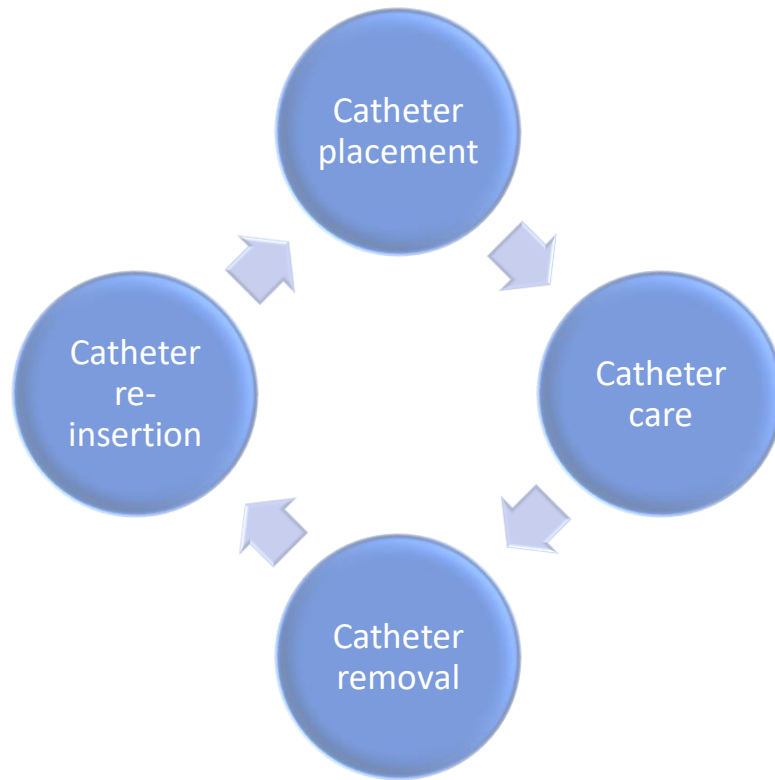


Figure I: Conceptual model of catheter lifecycle illustrating four stages (adapted from Meddings and Saint³⁶)

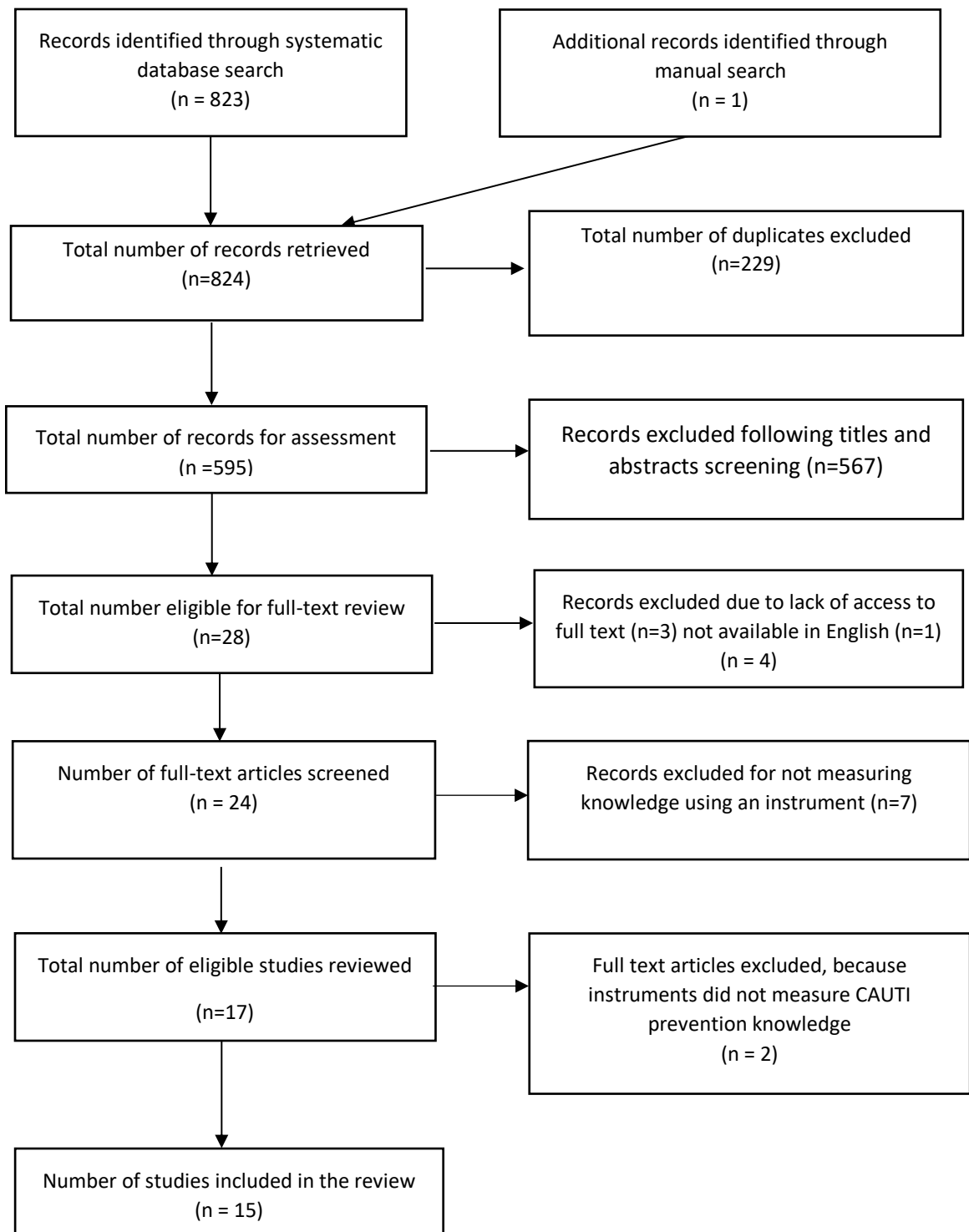


Figure II: Search results and studies selection process (adapted from Moher et al⁴²)

Appendages

Appendix I: Search terms used

“healthcare workers” OR hcw OR “healthcare professionals” OR nurses OR “nursing staff” OR “nursing students” OR doctors OR physician OR “medical staff” OR “medical students” AND knowledge OR understanding OR awareness OR education AND “catheter associated urinary tract infection” OR “catheter-related urinary tract infection” OR “urinary catheter infection prevention” OR cauti

Appendix II: Quality assessment using the COSMIN checklist for methodological quality assessment⁷²

Measurement property	Arlin & Bakan 2018	Gesmundo 2016	Drekonja et al., 2010a	Drekonja et al., 2010b	Mody et al., 2010	Paras et al., 2015	Shaver et al., 2018	Shah et al., 2017	Shehab, 2017	Fleming et al., 2000	Smith 2009	Jain et al., 2015	Viswanathan et al., 2015	Prasanna & adhika 2015	Kaur & Kumar 2017
Internal consistency: was an internal consistency statistic calculated for each sub-scale separately?	Y														Y*
for Classical Test Theory (CTT): was Cronbach's alpha calculated?	Y														
was sample size included in internal consistency analysis adequate?	Y														
Reliability (relative measures): were at least two measurements available?	Y										Y				
was the time interval stated?	Y														
were the test conditions similar for both measurements? (e.g. type of administration, environment)											Y				
was an intraclass correlation coefficient (for continuous variables) or a Kappa (for dichotomous/nominal/ordinal variables) calculated?															
Validity: Content validity: was there an assessment of whether all items refer to relevant aspects of the construct being measured?	Y				Y				Y			Y	Y		

was there an assessment of whether all items together comprehensively reflect the construct to be measured?	Y								Y		Y	Y			
Structural validity: was exploratory or confirmatory factor analysis performed? (for CTT)	Y														
were IRT tests for determining the (uni-)dimensionality of the items performed?															
Hypothesis testing: were hypotheses regarding correlations or mean differences formulated a priori (i.e. before data collection)?			*	*											
was the expected direction of correlations or mean differences included in the hypotheses?			Y												
was the expected absolute or relative magnitude of correlations or mean differences included in the hypotheses?			Y												
were design and statistical methods adequate for the hypotheses to be tested			Y	Y											